Mars and Earth: The quest for life

Module Overview

We know that life exists on this planet, but does it exist elsewhere in our solar system? People throughout history have looked to the stars as they pondered this question.
This module looks at human systems on Earth by using unique space-based observations. The module begins with investigations of how these observations are obtained and how they are interpreted. Earth observations from space play an important role in our everyday life. Each weather report we hear on the radio or see on television was developed with the aid of satellites orbiting Earth in space and observing weather patterns in the atmosphere. Farmers use satellite observations to measure the potential yield of their large crops. The military uses Earth observations from space to aid in our country's defense.

Along with Earth, this module studies Mars and the possibility that life existed, or perhaps may still exist, on that planet. Life on Mars has been debated since Percival Lowell thought he found evidence of canals on the Martian surface in the late 1800s. The comparison of Earth and Mars is accomplished by identifying and observing similar physical processes that exist on both worlds. Physical processes certainly affect living systems on Earth. Could they have the same effects on Mars? NASA has been studying Mars for decades and is developing plans that will one day send humans to the red planet to explore secrets which have eluded us for centuries.

This module is divided into four investigations. Each investigation may stand alone, or they may be linked for in-depth study.

***Investigation 1:* Where do we choose to live and why?**
In this investigation, students use a nighttime image to observe areas of light across the United States and to identify patterns and spatial distributions of human settlements. They explain the reasons for these patterns by answering questions and making inferences about what they observe. Then this knowledge is applied to identify similar patterns and spatial distributions on an unidentified region of the world using a color topographic map and nighttime image.

***Investigation 2:* How does remote sensing help us to observe human activities on Earth?**
Landscapes that are influenced by human activities are found nearly everywhere on Earth. In this investigation, students use remotely sensed images to identify features of New Orleans, Louisiana. Using two different remote sensing techniques, a Space Shuttle handheld camera photo and a Space Shuttle radar image, students compare and contrast the features visible on each image. They also discover the advantages of remote sensing and why it is a valuable tool for learning geography. Students

Geography Standards

The World in Spatial Terms
- **Standard 1:** How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective
- **Standard 3:** How to analyze the spatial organization of people, places, and environments on Earth's surface

Places and Regions
- **Standard 4:** The physical and human characteristics of places

Physical Systems
- **Standard 7:** The physical processes that shape the patterns of Earth's surface

The Uses of Geography
- **Standard 18:** How to apply geography to interpret the present and plan for the future

Science Standards

Unifying Concepts and Processes
- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement

Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Life Science
- Populations and ecosystems
- Diversity and adaptations of organism

Earth and Space Science
- Structure of the Earth system
- Earth in the solar system

Science and Technology
- Understandings about science and technology

Science in Personal and Social Perspectives
- Populations, resources, and environments
- Risks and benefits
- Science and technology in society

History and Nature of Science
- Science as a human endeavor

identify the following features on each image: human systems, features created by humans to adapt to their environment, surrounding natural features that are a positive influence on human systems, and surrounding natural features that are a negative influence on human systems.

***Investigation 3:* What similar physical processes occur on both Earth and Mars?**

Could life exist on Mars? This is a question that humans have wondered about for centuries. What physical processes on Earth led to an environment suitable for life? Do these physical processes also occur on Mars, and could they also create a suitable environment for life on that planet? This investigation compares and contrasts physical processes that occur on both Earth and Mars. Students are given unidentified images of Earth and Mars. Their task is to sort the images into pairs that show evidence of similar physical processes. Then they identify each image as being an area of Earth or an area of Mars by comparing and contrasting physical features that they observe in the image pairs.

***Investigation 4:* Is life on Mars possible and could humans establish settlements there?**

Humans will, within the next few decades, travel to Mars to explore the red planet. Those first explorers will become the 21st century's Christopher Columbus. Their primary objective will be to explore for evidence of life. This investigation allows students to become explorers. Students use images of Mars (those also used in Investigation 3) to locate regions in which to search for evidence of life and to build future settlements.

Connection to the Curriculum

The use of technology to observe Earth from space and to obtain space-based images is a major component of this module. This module employs geography and science by illustrating the physical processes that build our planet and affect living systems in many ways. Mathematics is an integral part of the module. It is used in problem solving and to determine spatial relationships on both Earth and Mars. Much has been written about Mars even before the 20th century. This literature can be an important complement to this module.

Time

Each of the investigations in this module takes one or two 45-minute sessions to complete.

Module Assessment

In this module, student performance may be assessed by evaluating the answers students record on the Investigation Logs. Participation in class discussions may be measured to assess learning. Most of the questions in the Investigation Logs do not require a right answer. Instead, answers are based on student perceptions as well as observations of geographic systems.

Mathematics Standards

Number and Operations

- Compute fluently and make reasonable estimates

Geometry

- Use visualization, spatial reasoning, and geometric modeling to solve problems

Technological Literacy Standards

Nature of Technology

- **Standard 1:** The characteristics and scope of technology
- **Standard 2:** The core concepts of technology
- **Standard 3:** Relationships among technologies and the connection between technology and other fields

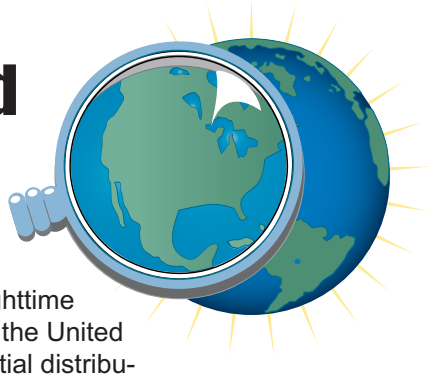
Technology and Society

- **Standard 6:** The role of society in the development and use of technology
- **Standard 7:** The influence of technology on history

Abilities for a Technological World

- **Standard 12:** Use and maintain technological products and systems
- **Standard 13:** Assess the impact of products and systems

Where do we choose to live and why?



Investigation Overview

In this investigation, students use a nighttime image to observe areas of light across the United States and to identify patterns and spatial distributions of human settlements. They explain the reasons for these patterns by answering questions and making inferences about what they observe. Then this knowledge is applied to identify similar patterns and spatial distributions on an unidentified region of the world using a color topographic map and nighttime image.

Time required: One or two 45-minute sessions

Materials/Resources

Briefing and Logs 1, 2, and 3 (one copy for each student)
Figure 2: United States at night puzzle (one per student or student group)
Figure 5: United States relief map (one per student or student group)
U.S. road/travel map or atlas
World map or globe
Overhead transparency sheet
Overhead markers (light colors)
Clear cellophane tape
Scissors

Content Preview

The spatial concepts of pattern, dispersion, and density help to analyze geographic distributions. Maps and images of the United States and other areas of the world provide the information needed to describe and explain the spatial distribution of settlements.

Classroom Procedures

Beginning the Investigation

1. To begin the investigation, have students examine a U.S. road map and discuss the distribution of the population and human settlement features such as cities, highways, transportation hubs, and other areas. A classroom atlas can be used, or U.S. road maps can be purchased at most stores or local travel agencies.

2. Have students identify and list any patterns they see. Some pattern examples are large concentrations of settlements separated by what appears to be unoccupied space, lines of settlement near water, and settlements located with respect to landforms, such as at the foot of mountains.

Geography Standards

Standard 1: The World in Spatial Terms

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

- Use geographic tools and technologies to pose and answer questions about spatial distributions and patterns on Earth.

Standard 3: The World in Spatial Terms

How to analyze the spatial organization of people, places, and environments on Earth's surface

- Analyze and explain distributions of physical and human phenomena with respect to spatial patterns, arrangements, and associations.

Geography Skills

Skill Set 4: Analyzing Geographic Information

- Interpret information obtained from maps, aerial photographs, satellite-produced images, and geographic information systems.
- Interpret and synthesize information obtained from a variety of sources—graphs, charts, tables, diagrams, texts, photographs, documents, and interviews.

Skill Set 5: Answering Geographic Questions

- Make generalizations and assess their validity.
- Develop and present combinations of geographic information to answer geographic questions.

3. Allow students to discuss the following questions:
   - Why are some areas empty and some areas more densely populated? (*Due to physical features such as water bodies, mountain ranges, or deserts.)*
   - How are these areas connected to each other? (*Via roads, rails, or air transportation.*)
   - Where do most of the larger cities seem to be located? (*In the eastern part of the country and along coasts.)* Why? (*Historical settlement pattern, rainfall, agriculture.*)

4. Three important terms associated with *spatial distribution* are used in this investigation: *pattern, dispersion,* and *density*. Have students define these terms in a class discussion or by using a dictionary. As an example of spatial distribution, have the students apply the new terms to the classroom setup. For example, what is the pattern of desks and chairs, and how dispersed or densely arranged are they?

Developing the Investigation

5. The investigation is divided into three sections that build upon each other. Each section has a series of questions that students answer. Students answer the questions on their own, in small groups, or in an educator-guided class discussion. The answers are based on what students observe in the images and the maps provided. A U.S. road map is needed. A shaded relief map of the United States (**Figure 5**) will be needed.

6. Distribute and have students read the **Briefing.**

7. Distribute **Log 1**. It guides students to a basic understanding of spatial concepts associated with human settlement patterns by using an image of the northeast region of the United States. The image shows the nighttime lights in this region. Discuss the information about spatial concepts with the students to assure their understanding before proceeding with the questions.

8. Distribute and read copies of the student pages for **Log 2** of this investigation. Also distribute copies of **Figure 2: United States at night puzzle**. **Figure 6** is an assembled United States at night puzzle image to use as a guide. **Log 2** builds upon what the students learned in Log 1. It uses a different image. The students must first assemble the puzzle made from pieces of an image of the nighttime lights of the United States and then answer questions about what they observe in the assembled image. This allows them to develop a better understanding of human settlement patterns. The questions are divided into three sections. Each level builds to a higher level of skills.

9. Have students cut out each segment of the U.S. image puzzle and assemble them. Ask them to use any patterns they see in each segment to guide them in the task. Students should use clear tape to attach the segments. Once the image is assembled, have students tape a clear overhead transparency over the image to allow them to use markers to label and identify the regions discussed in the questions they are to answer.

10. Instruct students to use their assembled U.S. image to answer the questions in **Log 2**.

11. **Log 3** asks students to make inferences about human settlements from a color topographic image of an unidentified region of the world (**Figure 3**). The region is Australia and New Zealand. On this image, the students identify suitable areas of settlement based on what they learned in **Logs 1** and **2**. After students complete their speculations on **Log 3a**, distribute **Log 3b** so they can check their answers by comparing their choices with a nighttime image of Australia (**Figure 4**).

Concluding the Investigation

12. In concluding the investigation, have students develop new questions that can be asked about the image. They must also be prepared to answer their new questions.

13. Guide students into discussions of possible future settlement patterns and influences of future population growth in the United States. An example may be that cities and urban areas continue to spread out using more and more land. Future settlement patterns may be influenced by road development, development of automated, computer-controlled autos, high-speed rail travel, and information technology such as computers and other electronic devices which allow people to work away from a specific factory or office and thus avoid commuting to work.

Background

Settlement Patterns

Why do you live where you live? Where do people choose to live? Why do they choose to live there? People have lived on Earth for thousands of years. Throughout history they have chosen particular settlement locations for many practical reasons. For just as many reasons they have packed up and moved to settle in other areas. Sometimes bloody wars have been fought over the right to settle in a particular

region. Also, natural hazards such as floods, earthquakes, and climate changes have influenced people to change the locations of their settlements. Cities, highways, roads, agricultural areas, industrial regions, and transportation hubs around the world are factors that contribute to the formation of human systems. When the United States was settled, early settlements began in the east and gradually moved westward. Could this be the reason the eastern United States is more densely populated than the west? What if the settlements began in the west and moved eastward instead? How would the United States look today?

NASA has been observing and studying Earth since 1958 with aircraft, spacecraft, satellites, and humans. These observations have generated millions of images and tremendous amounts of data. NASA Earth observations help geographers worldwide to study and answer many questions about human migration and settlement patterns. Where will human settlements be 10 years, 20 years, or even 100 years from now? Can humans build settlements on other worlds like Mars or our Moon? Will settlements of other planets become a necessity?

Nighttime Image

This map is a compilation of satellite images from the National Oceanic and Atmospheric Administration (NOAA), the National Geographical Data Center (NGDC), and the Defense Meteorological Satellite Program (DMSP) that show the continental United States at night. The image of the U.S. nighttime lights was derived from cloud-free portions of 231 orbits (October 1994 to March 1995) of DMSP Operational Linescan System (OLS) data. The majority of the detected features are lights from cities and towns. The arrangement of lights on this map is called *a spatial distribution*.

Spatial Distribution Concepts

There are three important concepts in locating items in space. They are *pattern, dispersion,* and *density*. *Pattern* refers to the arrangement of items within a distribution in terms of density, clustering, alignment, and orientation. *Dispersion* refers to whether items are clustered or spread out. *Density* means the number of items within a defined area. Examining the distribution of lights across the United States will help students understand these three concepts.

Evaluation

Log 1

1. Night
2. Space
3. Population
4. Absence of population
5. No
6. Students should see population clusters, linear arrangements of population, and even distribution and spacing between clusters.

Log 2

1. Answers may vary.
2. They are lakes.
3. Gulf of Mexico; offshore platforms
4. Rugged, arid terrain discourages population.
5. Answers will vary.
6. Answers will vary.
7. More people live along the coast.
8. Answers will vary.
9. Answers will vary.
10. Students may see that population densities are greater in the eastern portion of the United States than in the western portion.
11. Students may see linear patterns running east-west and north-south in the west and trending southwest to northeast in the east following the Appalachians. Answers will vary.
12. Students may observe that population is least dense in the drier regions of the United States.
13. Answers will vary, but there is a relationship between population and elevation and relief.

Resources

NASA Spacelink
http://spacelink.nasa.gov/
NASA Earth Science Enterprise
http://www.earth.nasa.gov/
National Oceanic and Atmospheric Administration (NOAA)
http://www.noaa.gov/
National Geophysical Data Center (NGDC)
http://www.ngdc.noaa.gov/
Defense Meteorological Satellite Program (DMSP)
http://www.ngdc.noaa.gov/dmsp/dmsp.html
U.S. Geological Survey (USGS)
http://www.usgs.gov/

Module 2, Investigation 1: Briefing
Where do we choose to live and why?

Background
Why do you live where you live? Where do people choose to live? Why do they choose those places? People have lived on Earth for thousands of years. Throughout history they have chosen particular settlement locations for many practical reasons. For just as many reasons they have packed up and moved to settle in other areas. Sometimes bloody wars have been fought over the right to settle in a particular region. Also, natural hazards such as floods, earthquakes, and climate changes have caused people's decisions to change the locations of their settlements.

Cities, highways, roads, agricultural areas, industrial regions, and transportation hubs around the world are factors that contribute to forming human systems. When the United States was settled, early settlements began in the east and gradually moved westward. Could this be the reason the eastern United States is more densely populated than the west? How does this historical migration affect current population patterns in the United States? What if the settlements had grown in the west and moved eastward instead? How would the United States look today?

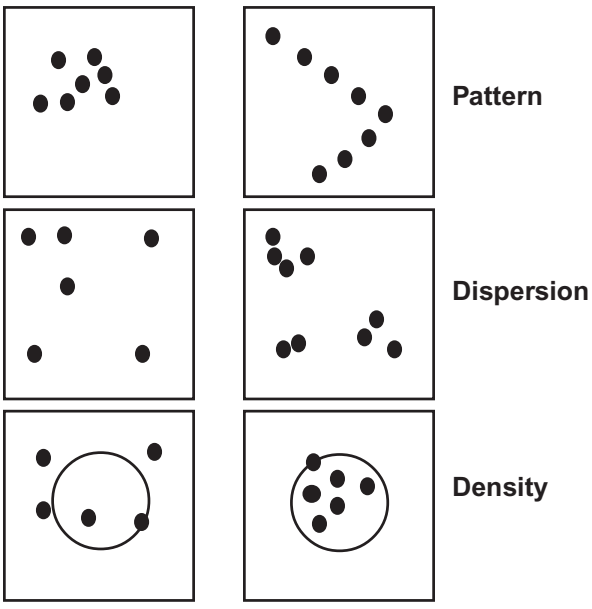
NASA has been observing and studying Earth since 1958. These observations have been made with aircraft, spacecraft, satellites, and humans on the ground. These observations have generated millions of images and tremendous amounts of data. NASA Earth observations have helped geographers worldwide study and answer many questions about human migration and settlement patterns by providing researchers with large-area views of our planet. Where will human settlements be 10 years, 20 years, or even 100 years from now? Can humans build settlements on other planets like Mars or our Moon? Will settlements of other planets become a necessity?

In this investigation, we look at one region of Earth using some unique and interesting perspectives including: images of Earth taken from space, a relief map, and a road map. Using these views we identify where human settlements are found and why these settlement patterns exist.

Objectives
Upon completion of this investigation, you will:
- understand different ways of observing Earth,
- understand ideas of spatial distribution and how these are used to understand human settlement patterns, and
- identify human settlements and patterns using maps and images.

In this investigation, you will learn spatial distribution concepts: *pattern, dispersion,* and *density*. You will accomplish this using an image of an unidentified location on Earth and answering questions about what you observe in that image.

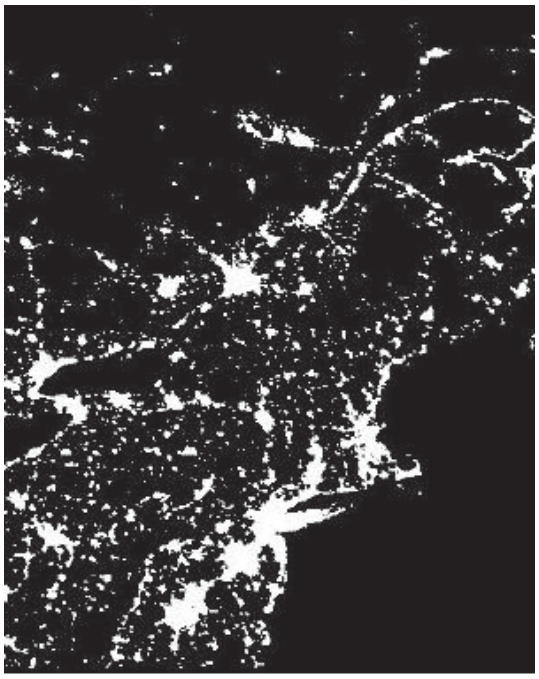
Spatial Concepts
The arrangement of things on Earth's surface is called *spatial distribution.* Observe these six sets of dots. Each square represents an equal area. Each one illustrates an important concept in the location of items in space. They are *pattern, dispersion,* and *density. Pattern* is the arrangement and design in the distribution. *Dispersion* relates to whether items are clustered or spread out. *Density* refers to the number of items or observations within a defined area.



Module 2, Investigation 1: Log 1
Where do we choose to live and why?

Directions: Apply the spatial distribution concepts to Figure 1 to answer the following questions.

Figure 1



Questions

1. During what time of the day was this image taken?

2. Do you think this image was taken from the ground, airplane, or space?

3. What do the areas of light on the image indicate?

4. What do the areas of dark on the image indicate?

5. Are the areas of light equally dispersed?

6. Do you see any patterns? If so, identify them.

7. Use a U.S. road map or atlas to:
   - identify and label specific cities, water bodies, roads, or other specific features; and
   - identify which part of the United States this image represents.

Module 2, Investigation 1: Log 2
Where do we choose to live and why?

Background
In Part B of this investigation, you will apply what you learned in Part A to assemble the segments of a "United States at night" image and answer questions regarding spatial distribution. Figure 1, in Log 1, shows the northeast section of the United States as seen at night from space. The image is a compilation of satellite images taken over several months (231 Earth orbits from October 1994 to March 1995) to avoid cloud cover. The white areas are lights, and the black areas are either an absence of lights over land or over bodies of water. Where there are lots of lights, there are lots of people. People choose to live where they do because of many factors. People tend to live where it is easy to make a living, is easy to get resources, it is not too wet or dry, it is not too cold or hot, and the land is not too rugged.

Procedures
1. Figure 2 is a complete "United States at night" image separated into eight random segments creating a puzzle. Following the directions below, assemble these segments to make an accurate image of the 48 contiguous states of the United States.

2. Assemble the segments of the image into the complete map of the United States by connecting features and patterns. Rely on your mental map of the United States to complete this task.

3. Lay an overhead transparency over the assembled image. Use this transparency and overhead markers to trace the map and complete the questions below.

4. Use a U.S. shaded relief map (Figure 5) and a U.S. road map or atlas to help answer the questions below.

Section One
1. What region(s) has/have the highest concentration of light? Why? Label these areas.

2. Identify and label the fingerlike areas of dark in the northeast section of the image. Why are they dark?

3. Identify and label the black region in the southern section. What are the smaller light areas located within this region?

4. Identify and label the area in the western region that is mostly dark. Why is it that way?

5. Locate and label where you live on the image. Is it in an area of light or dark?

Module 2, Investigation 1: Log 2
Where do we choose to live and why?

Section Two

6. Identify and label the 10 areas with the highest density of light. Use a road map to identify them.

7. Why do areas along coastlines, rivers, and lakes appear to have a relatively higher density of light?

8. Identify and label any major highways you can observe on the image.

9. Identify and label any major water bodies you can observe on the image.

Section Three

10. Describe the dispersion of population in the United States.

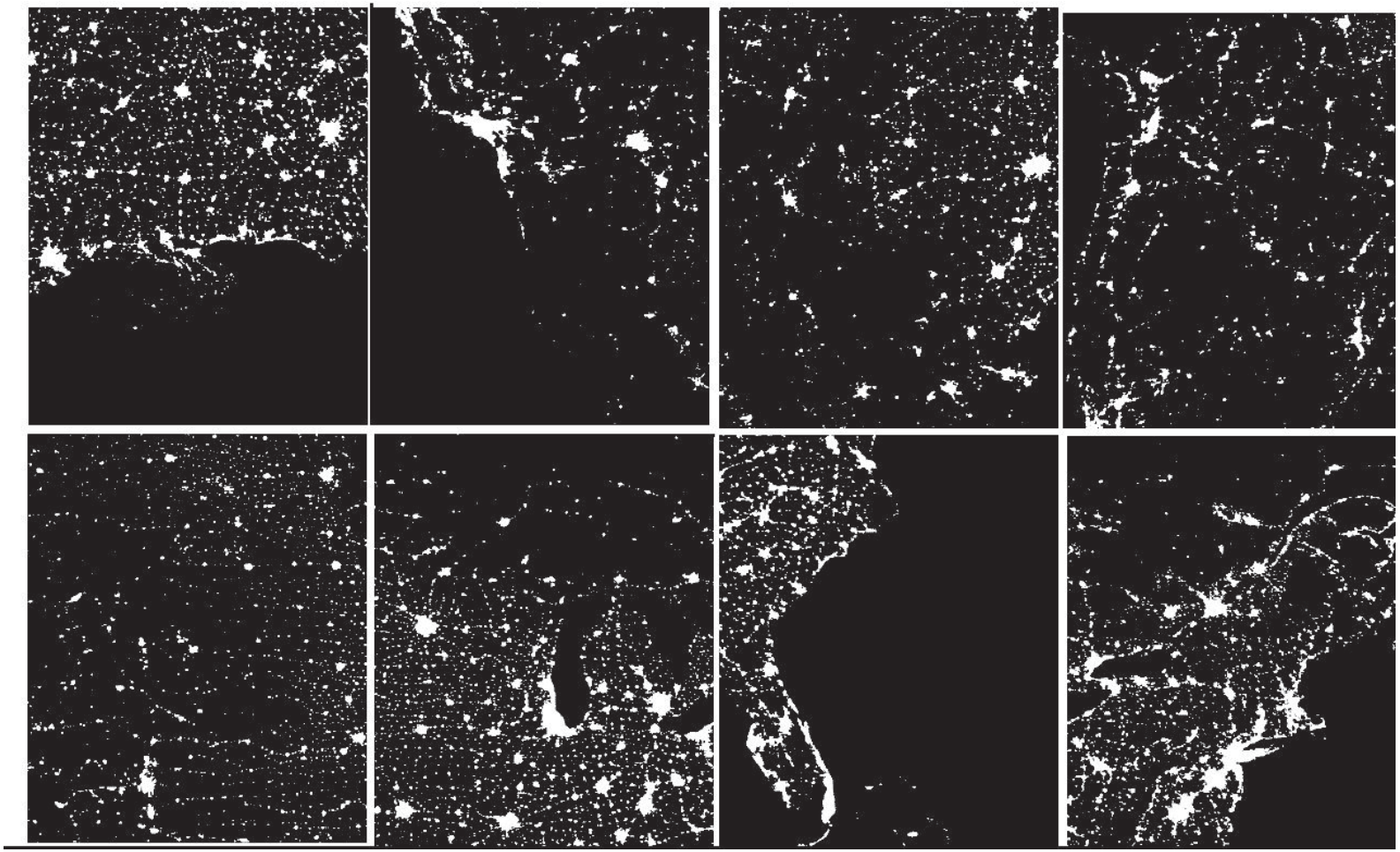
11. Identify and label any patterns you observe on the image.

12. Does the climate have any effect on the settlement patterns observed in the image? How?

13. Do elevation and relief have any effect on the settlement patterns observed in the image? How?

Module 2, Investigation 1: Figure 2

United States at night puzzle

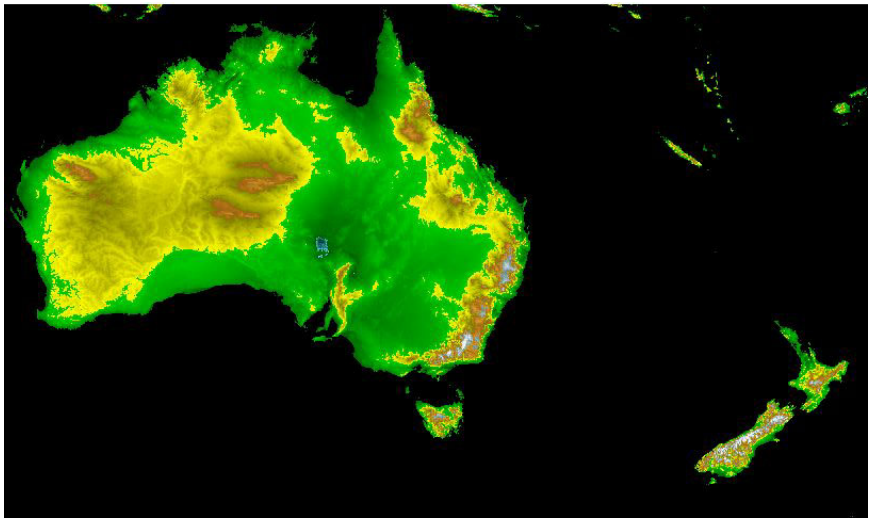


Module 2, Investigation 1: Log 3a
Where do we choose to live and why?

Procedures

Using the concepts you have learned so far about human settlement patterns, observe the topographic map (Figure 3) and identify locations that would best support human settlements. In the image, the different colors identify different elevations.

Figure 3: Color topographic image

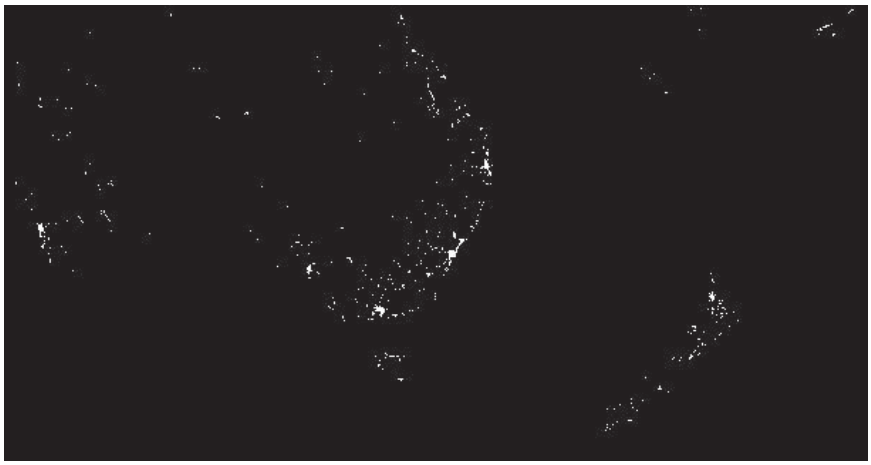


Elevation Key:

Lowest	dark green
	light green
	yellow
	tan
	brown
Highest	white

Module 2, Investigation 1: Log 3b
Where do we choose to live and why?

Figure 4



1. Observe the night image (Figure 4) of the same location. Were your predictions accurate according to what you observe in the night image? Why or why not?

2. Using a world map, identify the land masses and water bodies represented in Figures 3 and 4.

Module 2, Investigation 1: Figure 5

United States relief map

Module 2, Investigation 1: Figure 6

Assembled United States at night puzzle